Chapter 3
Substances and Properties

The main purpose of chemistry lessons is to acquaint students with nature or everyday phenomena and help them to understand what is going on in nature: all guidelines for chemical education, schoolbooks and most curricula should aim at achieving this goal. In addition, the principles of psychology require to offer phenomena which children and students have observed on their own. Based on these observations, they will find initial explanations and will develop their cognitive structure.

However, scientific concepts are often needed to understand the simplest natural phenomena. Whether it is the evaporation of a puddle or the burning of a piece of charcoal, correct interpretation can only be possible by studying the concepts of smallest particles, of the structure of matter, of the formation of atoms, ions or molecules. As long as young people are not aware of these concepts, they tend to develop their own ideas like, “the sun soaks up water from the puddle” or “weight decreases by burning” (see Sect. 2.1). In order to be able to eliminate such erroneous interpretations, chemistry teachers should be aware of preconceptions in the area of

- animistic modes of speech,
- concepts of transformation,
- concepts of miscibility,
- concepts of destruction,
- concepts of combustion, or
- concepts of “gases as non-substances”.

If teachers know about most of the preconcepts in these areas, they can better prepare for chemistry lessons; they should be able to discuss these concepts critically with students, and with the help of special media and technology, they will help students to overcome the preconcepts. It is especially useful to have suitable chemical experiments available, which can be performed after such discussions on these preconcepts. In this chapter, suitable methods of teaching will be presented without using the particle concept. In Chap. 4, a follow-up will be offered with diagnostic tools and teaching suggestions concerning the particle concept and Dalton’s atomic model.
3.1 Animistic Modes of Speech

The mental development of beginners in chemistry can be associated primarily with concrete thought operations according to Piaget: they are mainly fixed in their ideas on the specific object. This leads to the fact that they tend to describe such phenomena in a concrete-pictorial manner and in a magic-animistic mode of speech. The following examples have often been experienced:

- wood will not burn, the flame will extinguish, and the flame devours the candle,
- acids attack, they eat base metals, rust guzzles the body of the car, etc.

Pupils’ explanations often correlate with simple analogies, causes are personified:

- sodium metal reacts with water “like a fizzy tablet”,
- when copper sulfate dissolves, it is like “the way red cabbage runs in water”,
- crops grow in fields so that people can eat,
- wood burns, so that one can warm oneself, etc.

Püttschneider and Lück [2] discuss the role of animism in the teaching of chemical topics and propose the following points: “(1) Using animisms consciously generates a positive association to the subject of chemistry, (2) animisms tend to have a lasting motivational effect because they help the students comprehend the subject, (3) the students are aware of the model character of the animisms” [2]. Initial results show that “animisms lead to better understanding thereby having a lasting motivational effect” [2].

**Teaching and Learning Suggestions.** At first, it is obvious that the above pupils’ statements use everyday language and the pertinent observations based on this fact are easy to comprehend: every person knows what is meant when somebody says, “the wood will not burn”. Therefore, one should not state these forms of expression as incorrect.

If there is enough lecture time and the question comes up from the students regarding a so-called “will of wood”, one should elucidate this topic. One could discuss whether a damp piece of wood is always hard to ignite, or if wood contains a “will” of its own, if it is “sometimes easy to light and sometimes difficult, depending on the wood’s will”. The question arises as to whether it could be, that small dry pieces of wood are always easy to ignite and continue to burn? In this discussion, the statement “the wood will not burn” can be restated depending on the conditions under which wood can easily be ignited or not. One could even show that different types of wood react differently and that, for instance, birch bark belongs to the type of wood, which contains easily ignitable resin and is therefore ideal for starting up a campfire. When the fire is finally lit, one can warm oneself from it: man uses fire with the intention of having “light and warmth”. Wood burns when a person wants it to and when he or she is in a position to ignite it – it is not the wood “which decides” when and if a person needs warmth.